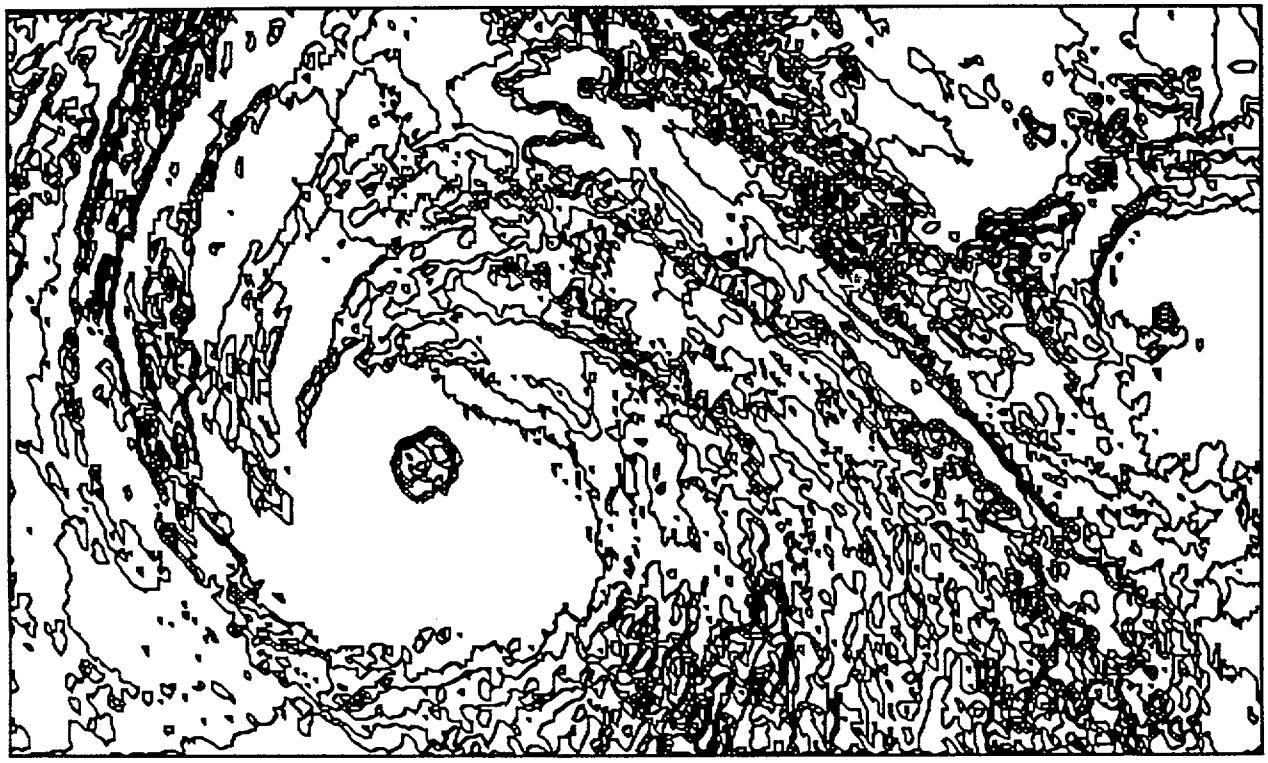
1988 ANNUAL TROPICAL CYCLONE REPORT



JOINT TYPHOON WARNING CENTER
GUAM, MARIANA ISLANDS

FRONT COVER: Contouring of visual satellite imagery enhances the cloud topography of Typhoon Hal (14W) with its large ragged eye and (at the right edge of the picture) the comma shape of Tropical Storm Irma (15W). These two tropical cyclones were active with Tropical Storm Jeff (16W) and Typhoon Uleki (01C) during the second week of September.

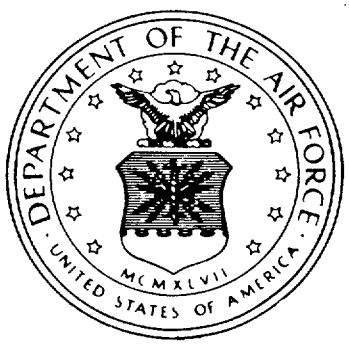
U. S. NAVAL OCEANOGRAPHY COMMAND CENTER
JOINT TYPHOON WARNING CENTER
COMNAVMARIANAS BOX 17
FPO SAN FRANCISCO, CA 96630

ROBERT J. PLANTE

CAPTAIN, UNITED STATES NAVY
COMMANDING OFFICER

DANIEL J. McMORROW

LIEUTENANT COLONEL, UNITED STATES AIR FORCE
DIRECTOR, JOINT TYPHOON WARNING CENTER
COMMANDER, DETACHMENT 1, 1ST WEATHER WING



STAFF

JOINT TYPHOON WARNING CENTER

* LCDR	GEORGE M. DUNNAVAN	USN
LCDR	JOHN L. HEISHMAN	USN
* LCDR	BRIAN J. WILLIAMS	USN
* CAPT	STEVEN B. DREKSLER	USAF
LT	RICHARD H. BOUCHARD	USN
CAPT	ROBERT F. CROSBY	USAF
LT	RYAN R. SCHULTZ	USN
* LT	STEVE J. FATJO	USN
CAPT	JOHN M. ROGERS	USAF
CAPT	JOHN D. PICKLE	USAF
** LT(JG)	STACY R. STEWART	USNR-R
1LT	ROBERT J. FALVEY	USAF
ENS	RICHARD L. JEFFRIES	USN
* AG2	RAYMOND L. BROOKS	USN
SSGT	DONALD L. NOVAK, JR.	USAF
AG2	BARRY F. BROCKMAN	USN
* SSGT	MICHAEL P. STEELE	USAF
* AG3	DEANNA L. WILHITE	USN
* AG3	SHIRLEY A. MURDOCK	USN
SGT	ANGELIA C. BLAISDELL	USAF
SGT	JAMES B. WIEMANN	USAF
* AG3	SEAN L. KLOPE	USN
SGT	JAMES B. BUNKER	USAF
SRA	DONALD L. MILLER	USAF
AG3	JEFFERY L. CHAPIN	USN
AG3	KIMBERLEY J. WOODS	USN
AGAN	AVERY G. DUNCAN	USN
AGAN	JEREMY D. WILLIAMS	USN

DET 1, 1WW SATELLITE OPERATIONS

MAJ	JOEL D. MARTIN	USAF
* CAPT	DAN B. MUNDELL	USAF
* CAPT	KENNETH W. REESE	USAF
1LT	TIM D. HUTCHISON	USAF
MSGT	ROBERT E. REDINGER	USAF
MSGT	CHARLES J. BONINI	USAF
* MSGT	JEFFERY L. FLEMING	USAF
TSGT	TONI D. HUMPHREY	USAF
* TSGT	ALAN W. ROBB	USAF
SSGT	ROBERT C. GRAY	USAF
SSGT	JACK L. WILSON	USAF
SSGT	WAYNE I. GENTRY	USAF
SSGT	PAUL F. HARPER	USAF

EDITORS

LT	DOUGLAS H. SCOVIL, JR.	USN
MR	FRANK H. WELLS	CIV

* TRANSFERRED DURING 1988
** ON ACTIVE DUTY TRAINING WITH JTWC

DISTRIBUTION LIST

1 COPY
BRUNEI SHELL PETROLEUM CO
BUREAU OF METEOROLOGY RESEARCH CENTER
CATHOLIC UNIVERSITY OF AMERICA
CENTRAL MET OBSERVATORY, BEIJING
CENTRAL METEOROLOGICAL OFFICE, SEOUL
CHULALONGKORN UNIVERSITY, BANGKOK
CHUNG CHENG INSTITUTE, TAIWAN
CITIES SERVICES OIL GAS CORP
CIUDAD UNIVERSITARIA, MEXICO
CIVIL DEFENSE, SAIPAN
CINCPACFLT
CNO (OP-096)
CNO (OP-096T)
CNO (OP-981D)
CNO (OP-943G)
COLORADO STATE UNIVERSITY LIBRARY
COMNAVOCEANCOM
COMNAVSURFGRU WESTPAC
COMNAVSURFPAC
COMPHIBGRU ONE
COMSC
COMSEVENTHFLT
COMSUBGRU SEVEN
COMTHIRDFLT
CONGRESSIONAL INFORMATION SERVICE, MD
DCA GUAM
DET 2, 20 WS
DET 4, 20 WS
DET 5, 20 WS
DET 8, 20 WS
DET 10, 30 WS
DET 13, 20 WS/CC
DET 15, 30 WS
DET 17, 20 WS
DISASTER CONTROL OFFICE, SAIPAN
ECMWF, BERKSHIRE, UK
FAIRECONRON ONE
FOREST DIVISION, JMA
GEOLOGICAL FLUID DYNAMICS LAB, PRINCETON, NJ
GEOLOGICAL SURVEY, GUAM
GODDARD SPACE FLIGHT CENTER
GUAM PUBLIC LIBRARY
HQ AWS/DN
HQ MAC/DOOS
HQ USAF/XOORZ
HUGHES AIRCRAFT CO
INSTITUO DE GEOFISICA, MEXICO
JCS ENV SERVICES DIV (J3(OES))
LOS ANGELES PUBLIC LIBRARY
MASS INST OF TECH
MCAS KANEOHE BAY HI
METEOROLOGY DEPT, BANGKOK
MOBIL OIL GUAM INC
MOUNTAIN STATES WEATHER SERVICES
NATIONAL TAIWAN UNIVERSITY
NAVAL CIVIL ENG LAB, PORT HUENEME, CA
NAVDEP NOAA
NAVEASTOCEANCEN NORFOLK
NAVHISTCEN
NAVOCEANCOMCEN ROTA
NAVOCEANCOMDET AGANA
NAVOCEANCOMDET ALAMEDA
NAVOCEANCOMDET ASHEVILLE
NAVOCEANCOMDET ATSUGI
NAVOCEANCOMDET BARBERS POINT
NAVOCEANCOMDET KADENA
NAVOCEANCOMDET MONTEREY
NAVOCEANCOMFAC YOKOSUKA
NAVPGSCOL LIBRARY
NAVPOLAROCEANCEN SUITLAND
NAVAL RESEARCH LAB
NOAA/ACQUISITION SECTION, ROCKVILLE, MD
NOAA/AOML, HRD, MIAMI, FL
NOAA/HYDROMETEOROLOGY BR, SILVER SPRINGS, MD
NOAA/NESDIS, REDWOOD CITY, CA
NOAA/PMEL, SEATTLE, WA
NOAA LIBRARY, MIAMI, FL
NOBEL DENTON
OCEAN ROUTES INC, CA
OCEANO SERVICES INC. LIBRARY
OCEANWEATHER, INC.
OFFICE OF NAVAL RESEARCH
PACIFIC STARS & STRIPES
PACNAVFACENGCOM
PENNSYLVANIA STATE UNIVERSITY
SRI LIBRARY
TEXAS A & M UNIVERSITY
UNIVERSITY OF CHICAGO
UNIVERSITY OF GUAM, BIOLOGY DEPT
UNIVERSITY OF HAWAII (LIBRARY)
UNIVERSITY OF WASHINGTON
USCINCPAC
USCINCPAC REP GUAM
USCINCPAC REP PHILIPPINES
USNA (OCEANOGRAPHY DEPT/LIBRARY)
USS AMERICA (CV 66)
USS BELLEAU WOOD (LHA 3)
USS CARL VINSON (CVN 70)
USS CONSTELLATION (CV 64)
USS CORAL SEA (CV 43)
USS EISENHOWER (CVN 69)
USS ENTERPRISE (CVN 65)
USS FORRESTAL (CV 59)
USS INDEPENDENCE (CV 62)
USS IOWA (BB 61)
USS J. F. KENNEDY (CV 67)
USS KITTY HAWK (CV 63)
USS LINCOLN (CVN 72)
USS MIDWAY (CV 41)
USS MISSOURI (BB 63)
USS NEW JERSEY (BB 62)
USS NEW ORLEANS (LPH 11)
USS NIMITZ (CVN 68)
USS OKINAWA (LPH 3)
USS PELELIU (LHA 5)
USS RANGER (CV 61)
USS SARATOGA (CV 60)
USS TARAWA (LHA 1)
USS TRIPOLI (LPH 10)
USS T. ROOSEVELT (CVN 71)
USS WISCONSIN (BB 64)
WORLD DATA CENTER B1, MOSCOW
WORLD WEATHER BUILDING, MD

3AD/DO
3WW/CC
3WW/DN
7WW/OL-A
20 WS/DO
30WS/DO
34 AWF, 920 WRG
43 SW/DO
3350 TCHTG/TTMV-S

2 COPIES
AFGWC/WFMP
AWS/DOOF
BUREAU OF METEOROLOGY, BRISBANE
BUREAU OF METEOROLOGY, DARWIN
BUREAU OF METEOROLOGY, PERTH
BUREAU OF PLANNING, GUAM
DEPARTMENT OF COMMERCE
ESCAP LIBRARY, BANGKOK
FLENUMOCEANCEN MONTEREY
FLORIDA STATE UNIVERSITY
HQ AWS/DOR
HQ AWS GP, JAPAN
INSTITUTE OF PHYSICS, TAIWAN
MARATHON OIL CO, TX
MARINERS WEATHER LOG
MCAS FUTENMA
MET RESEARCH INST LIBRARY, TOKYO
METEOROLOGY SOCIETY OF NEW SOUTH WALES, AUST
MICRONESIAN RESEARCH CENTER UOG, GUAM
NATIONAL CLIMATIC DATA CENTER
NATIONAL METEOROLOGICAL LIBRARY, BRACKNELL, UK
NATIONAL WEATHER OFFICE, PAGASA
NATIONAL WEATHER SERVICE, HONOLULU
NAVOCEANCOMDET DIEGO GARCIA
NAVOCEANCOMDET MISAWA
NAVOCEANCOMFAC CUBI PT
NAVOCEAN COMFAC JACKSONVILLE
NAVWESTOCEANCEN PEARL HARBOR
NOAA CORAL GABLES LIBRARY
NOAA GUAM
OKINAWA METEOROLOGY OBSERVATORY
PACAF/DOW
SAT APPL LAB, NOAA/NESDID, CAMP SPRINGS, MD
SAT APPL LAB, NOAA/NESDIS, REDWOOD CITY, CA
TYPHOON COM SECR, MANILA
UNIVERSITY OF PHILIPPINES
US ARMY, FORT SHAFTER
WORLD DATA CENTER A, NOAA
17 WS/DON
23 AF/HQ
73 WEATHER GROUP, ROK AF

3 COPIES
AWS TECH LIBRARY
BUREAU OF METEOROLOGY, MELBOURNE
CENTRAL WEATHER BUREAU, TAIWAN
HQ AWS/DN
INDIA METEOROLOGICAL DEPT
INOSHAC, DDGM (WF)
JAPAN METEOROLOGY AGENCY
MCAS IWAKUNI
NATIONAL HURRICANE CENTER, MIAMI
NAVPGSCOL DEPT OF METEOROLOGY
UNIVERSITY OF HAWAII, METEOROLOGY DEPT
1WW/DN

4 COPIES
COLORADO STATE UNIVERSITY
METEOROLOGY DEPT, BANGKOK
NATIONAL WEATHER ASSOCIATION
5WW/CC

5 COPIES
CIVIL DEFENSE, GUAM
PAGASA WEATHER BUREAU, RP
R & D UNIT, NHC, MIAMI
ROYAL OBSERVATORY HONG KONG

6 COPIES
NEPRF

12 COPIES
DEFENSE TECHNICAL INFORMATION CENTER

FOREWARD

The Annual Tropical Cyclone Report is prepared by the staff of the Joint Typhoon Warning Center (JTWC), a combined Air Force/Navy organization operating under the command of the Commanding Officer, U.S. Naval Oceanography Command Center/Joint Typhoon Warning Center, Guam. JTWC was established in April 1959 when USCINCPAC directed USCINCPACFLT to provide a single tropical cyclone warning center for the western North Pacific region. The operations of JTWC are guided by CINCPACINST 3140.1S.

The mission of the Joint Typhoon Warning Center is multi-faceted and includes:

1. Continuous monitoring of all tropical weather activity in the northern and southern hemispheres, from 180 degrees longitude westward to the east coast of Africa, and the prompt issuance of appropriate advisories and alerts when tropical cyclone development is anticipated.

2. Issuing warnings on all significant tropical cyclones in the above area of responsibility.

3. Determination of reconnaissance requirements for tropical cyclone surveillance and assignment of appropriate priorities.

4. Post-storm analysis of all significant tropical cyclones occurring within the western North Pacific and North Indian Oceans, which includes an in-depth analysis of tropical cyclones of note and all typhoons.

5. Cooperation with the Naval Environmental Prediction Research Facility (NEPRF), Monterey, California, on the operational evaluation of tropical cyclone models and forecast aids, and the development of new techniques to support operational forecast scenarios.

Satellite imagery used throughout this report represents data obtained by the DMSP network. The personnel of Detachment 1, 1WW, collocated with JTWC at Nimitz Hill, Guam, coordinate the satellite acquisitions and tropical cyclone reconnaissance with the following units:

Det 4, 20WS, Hickam AFB, Hawaii

Det 5, 20WS, Clark AB, Republic of the Philippines

Det 8, 20WS, Kadena AB, Japan

Det 15, 30WS, Osan AB, Korea

Air Force Global Weather Central, Offutt AFB, Nebraska

In addition, the Naval Oceanography Command Detachment, Diego Garcia, and Defense Meteorological Satellite Program (DMSP) equipped U.S. Navy ships have been instrumental in providing vital fixes of tropical cyclones in the Indian Ocean from satellite data.

Should JTWC become incapacitated, the Alternate Joint Typhoon Warning Center (AJTWC) located at the U.S. Naval Western Oceanography Center, Pearl Harbor, Hawaii, assumes warning responsibilities. Assistance in determining satellite reconnaissance requirements, and in obtaining the resultant data, is provided by Det 4, 20WS Hickam AFB, Hawaii.

Special thanks to: Navy Captain Carl W. Hoffman for his significant contributions and support; the men and women of the 27th Communications Squadron, Operating Location Charlie and the Operations department of the Naval Oceanography Command Center, Guam for their continuing support by providing high quality real-time satellite imagery; Marine Corps Air Station, Futenma, Japan for sharing their satellite imagery of STY Nelson (20W); the Pacific Fleet Audio-Visual Center, Guam for their assistance in the reproduction of satellite data for this report; to the Navy Publications and Printing Service Branch Office, Guam; the Royal Observatory Hong Kong for supporting synoptic data on TS Mamie (19W) and TY Ruby (23W); Dr. Bob Abbey and the Office of Naval Research for their technical support to this publication and support to the University of Hawaii for the Post Doctorate Fellow at JTWC; Dr. Mark Lander for his training efforts, suggestions and detailed work on CSUM; Dr. Greg Holland for his work with Major Joel Martin to develop a more representative periphery wind technique; the Australian Meteorological Service for the coastal radar reports on tropical cyclones via the AFTN to JTWC; Mr. Andy Chun and the CPHC for the data package on TY Uleki (01C); the Royal Navy and Royal Observatory Hong Kong for making possible the liaison visit by Lt. Cmdr. David Gray; National Weather Service Pacific Region for the startup of 24-hour operations at Ponape, Truk, Majuro and Koror, the retrieval of the HANDAR observations from their computer in Hawaii for TY Roy (01W), and Mr. Tom Yoshida for the development of the Tropical Cyclone Reporting Form for post-storm support to JTWC; First Weather Wing for expediting the delivery of the Alden receiver for PACDIGS; and the Federated States of Micronesia for endorsing the AMOS installation on Faraulep Atoll.

Note: Appendix IV contains information on how to obtain past issues of the Annual Tropical Cyclone Report (titled Annual Typhoon Report prior to 1980).

TABLE OF CONTENTS

INDIVIDUAL TROPICAL CYCLONES

CONTRACTIONS

ABIO	Significant Tropical Weather Advisory for the Indian Ocean
ABPW	Significant Tropical Weather Advisory for the Western Pacific Ocean
ACFT	Aircraft
ADP	Automated Data Processing
AFGWC	Air Force Global Weather Central
AIREP	Aircraft (Weather) Report (Commercial and Military)
AMOS	Automatic Meteorological Observing Station
AOR	Area of Responsibility
APT	Automatic Picture Transmission
ARGOS	International Service for Drifting Buoys
ATCF	Automated Tropical Cyclone Forecast System
ATCM	Advanced Tropical Cyclone Model
AUTODIN	Automated Digital Network
AWDS	Automated Weather Distribution System
AWN	Automated Weather Network
BT LAT	Best Track Latitude
BT LON	Best Track Longitude
BT WN	Best Track Wind
CDO	Central Dense Overcast
CI	Cirriform Cloud or Cirrus (or) Current Intensity (Dvorak)
CINCPAC	Commander-in-Chief Pacific AF - Air Force, FLT - Navy
CLD	Cloud
CLIM	Climatology
CLIPER	Climatology and Persistence Technique
CM	Centimeter
CNOC	Commander Naval Oceanography Command
COSMOS	Cyclops Objective Steering Model Output Statistics
CPA	Closest Point of Approach
CPHC	Central Pacific Hurricane Center
CSC	Cloud System Center
CSUM	Colorado State University (CSU84) Model
CYCLOPS	Tropical Cyclone Steering Program (HATTRACK and MOHATT)
DDN	Defense Data Network
DEG	Degree
DFS	Digital Facsimile System
DMSP	Defense Meteorological Satellite Program
DSAT	Digital Satellite Acquitition System
DSN	Defense Switched Network
DTG	Date Time Group
DWIPS	Digital Weather Image Processing System
FI	Forecast Intensity (Dvorak)
FNOC	Fleet Numerical Oceanography Center
FT	Feet
GMT	Greenwich Mean Time
GOES	Geostationary Operational Environmental Satellite
HATTRACK	Hurricane and Typhoon Tracking and Steering Program
HPAC	Mean of XTRP and CLIM Techniques (Half Persistence and Climatology)
HR(S)	Hour(s)
ICAO	International Civil Aviation Organization
INIT	Initial
INJAH	North Indian Ocean Component of TYAN
INST	Instruction
IR	Infrared
JTWC	Joint Typhoon Warning Center
JTWC-AP	Joint Typhoon Warning Center Automation Project
KM	Kilometer(s)
KT	Knot(s)
LAN	Local Area Network
LLCC	Low-Level Circulation Center
LVL	Level
M	Meter(s)
MAX	Maximum
MB	Millibar(s)
MDUS	Medium-scale Data Utilization System
MDUS-R	Medium-scale Data Utilization System Replacement
MET	Meteorological
MIN	Minimum
MOHATT	Modified HATTRACK
MOVG	Moving
MSLP	Minimum Sea-level Pressure
NARDAC	Naval Regional Data Automation Center

NEDN	Naval Environmental Data Network
NEDS	Naval Environmental Display Station
NEPRF	Naval Environmental Prediction Research Facility
NESDIS	National Environmental Satellite, Data, and Information Service
NM	Nautical Mile(s)
NOAA	National Oceanic and Atmospheric Administration
NOCC	Naval Oceanography Command Center
NODDES	Naval Environmental Data Network Oceanographic Data Distribution and Expansion System
NODDS	Navy/NOAA Oceanographic Data Distribution System
NOGAPS	Navy Operational Global Atmospheric Prediction System
NORAPS	Navy Operational Regional Atmospheric Prediction System
NSDS	Naval Satellite Display System
NWOC	Naval Western Oceanography Center
NWS	National Weather Service
NR	Number
NRL	Naval Research Laboratory
OBS	Observations
ONR	Office of Naval Research
OTCM	One Way (Interactive) Tropical Cyclone Model
PACDIGS	Pacific Digital Information Graphics System
PACMEDS	Pacific Meteorological Data System
PACOM	Pacific Command
PCN	Position Code Number
PIREP	Pilot Weather Report(s)
POS ER	(Initial) Position Error
RADOB	Radar Observation
RECON	Reconnaissance
RRDB	Reference Roster Data Base
RSDB	Raw Satellite Data Base
SAT	Satellite
SEC	Second
SDHS	Satellite Data Handling System
SFC	Surface
SGDB	Satellite Global Data Base
SLP	Sea-Level Pressure
SRP	Selective Reconnaissance Program
SST	Sea Surface Temperature
STNRY	Stationary
ST	Subtropical
STR	Subtropical Ridge
STY	Super Typhoon
TAPT	Typhoon Acceleration Prediction Technique
TC	Tropical Cyclone
TCFA	Tropical Cyclone Formation Alert
TD	Tropical Depression
TDA	Typhoon Duty Assistant
TDO	Typhoon Duty Officer
TIROS	Television Infrared Observational Satellite
TOGA	Tropical Ocean Global Atmosphere
TS	Tropical Storm
TUTT	Tropical Upper-Tropospheric Trough
TY	Typhoon
TYAN	Typhoon Analog (Program)
TYFN	Western North Pacific Component (Revised) of TYAN
TYMNET	Time-Sharing Network: Commercial wide area network connecting micro- and mainframe computers
ULAC	Upper-Level Anticyclone
ULCC	Upper-Level Circulation Center
USAF	United States Air Force
USN	United States Navy
VIS	Visual
WESTPAC	Western (North) Pacific
WMO	World Meteorology Organization
WRNG(S)	Warning(s)
WW ER	Wind Warning Error
W#	Warning Number
XTRP	Extrapolation
Z	Zulu Time (Greenwich Mean Time)
24 ER	24-Hour (Position) Error
48 ER	48-Hour (Position) Error
72 ER	72-Hour (Position) Error
24 WE	24-Hour Wind (Warning) Error
48 WE	48-Hour Wind (Warning) Error
72 WE	72-Hour Wind (Warning) Error

Intentionally left blank.